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EXPERIMENTAL INVESTIGATION OF TOOL WEAR RATE IN DEBURRING OF CP TITANIUM GRADE-2 BY ELECTRICAL DISCHARGE MACHINING

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ABSTRACT
Burrs are sharp edged disfiguration produced by certain machining processes, such as shearing, drilling, milling and turning operation. Typically, they take the form of the thin fins on the edge of specimens, although the environment of these projections is dependent on the machining process. Deburring is a prerequisite for a number of processes such as electroplating, and powder coating since it is allow for uniform application of the finishing material. CP Titanium (Ti) Grade 2 may be considered in any purpose where formability and corrosion resistance are important, and strength requirements are moderate. CP Titanium Grade 2 is widely used because it combines excellent formability and reasonable strength with greater corrosion resistance. Through Electrical Discharge Machine (EDM) removal of Burr can be performed with the help of Copper and Brass electrode. In the present research work Deburring was done with varying input control variable and its effect on the Tool Wear (TW) was investigated. Minitab 17 software was used to perform the statistical analysis and to obtain combination of the Optimum level of parameter for minimum Tool Wear Rate (TW).Tool Wear Rate for Signal to Noise Ratios- "Smaller-is-better" factor was highly affected by SF followed by TON and IB.

KEYWORDS: Deburring, Corrosion Resistance ,TON and IB

INTRODUCTION The tool wear rate (TWR), can be defined as describes the gradual failure of cutting tools due to regular operation (Malakooti, B; Deviprasad, J 1989). It is an expression often connected with tipped tools, tool bits, or drill bits that are used with machine tools (S. Kalpakjian and S.R. Schmidt, Manufacturing Engineering and Technology. 2000, Prentice Hall, Upper Saddle River, NJ). Another way to define TWR is to imagine an "instantaneous" material removal rate as the rate at which the cross-section area of material being separated from the work piece. Some General effects of tool wear include increased cutting forces, increased cutting temperatures and decreased accuracy of finished part. Electrical Discharge Machining (EDM), consists of an electrode and work piece sunken in an insulating liquid such as, more typically (Jameson, E. C. 2001), oil or, less frequently, other dielectric fluids. The electrode and work piece are connected to a suitable power supply. The power supply generates an electrical potential between the two parts. As the electrode approaches the work piece, dielectric breakdown occurs in the fluid, forming a plasma channel and a small spark jumps. Copper is a chemical element with symbol Cu (from Latin : *cuprum*) and atomic number 29. It is a soft, malleable and ductilemetal with very high thermal and electrical conductivity. They have one s-orbital electron on top of a filled d-electron shell and are characterized by high ductility and electrical and thermal conductivity (Pleger, Thomas C. "A Brief Introduction to the Old Copper Complex of the Western Great Lakes: 4000–1000 BC).

METHODOLOGY
For the present research work the experiment work was designed strategically using the DOE (Design of Experiment) statistical tool. The design of experiments (DOE, or experimental design) is the design of any task that aims to describe or explain the variation of information under conditions that are hypothesized to reflect the variation. The term is generally associated with true experiments in which the design introduces conditions that directly affect the variation, but may also refer to the design of quasi-experiments, in which natural conditions that influence the variation are selected for observation. In its simplest form, an experiment aims at predicting the outcome by introducing a change of the preconditions, which is reflected in a variable called the predictor. The change in the predictor is generally hypothesized to result in a change in the second variable, hence called the outcome variable. Experimental design involves not only the selection of suitable predictors and outcomes, but planning the delivery of the experiment under statistically optimal conditions given the constraints of available resources. Main concerns in experimental design include the establishment of validity,

reliability, and replicability. Orthogonal array testing is a black box testing technique that is a systematic, statistical way of software testing. It is used when the number of inputs to the system is relatively small, but too large to allow for exhaustive testing of every possible input to the systems. It is particularly effective in finding errors associated with faulty logic within computer software systems. Orthogonal arrays can be applied in user interface testing, system testing, regression testing, configuration testing and performance testing. The permutations of factor levels comprising a single treatment are so chosen that their responses are uncorrelated and therefore each treatment gives a unique piece of information. The net effects of organizing the experiment in such treatments are that the same piece of information is gathered in the minimum number of experiments. For this reason L18 array was selected and the following control input variable with different level has been used.

Table No.1: EDM Process Parameters and their Levels

Parameters	Tw	TON (Pulse on)	TAU (Pulse Off)	IP	IB	TDI	SV	SF
Level 1	10	150	16	18	2	60	75	30
Level 2	20	400	20	25	3	70	80	50
Level 3	--	750	24	32	4	80	85	70

The output parameter measured was the Tool Wear Rate.
For this present research work CP Titanium (Ti) grade2 was selected as specimen material.
Titanium is a chemical element with symbol Titanium (Ti) and atomic number 22. It is a lustrous transition metal with a silver colour, low density and high strength. It is highly resistant to corrosion in sea water, aqua regia, and chlorine (Andersson, N.; et al. 2003). Titanium can be alloyed with iron, aluminum, vanadium,
and molybdenum, among other elements, to produce strong, lightweight alloys.

Application of Titanium and CP Titanium Grade 2:-

1. In aerospace (jet engines, missiles, and spacecraft)
2. Military and Industrial process (chemicals and petro-chemicals, desalination plants, pulp, and paper)
3. Automotive
4. Agri-food, medical prostheses
5. Orthopedic implants, dental and endodontic instruments and files, dental implants,
6. Jewelry, mobile phones, and other applications.
7. Titanium is used in steel as an alloying element (ferro-titanium) to reduce grain size and as a deoxidizer, and in stainless steel to reduce carbon content.

Table No. 2: Chemical composition of CP Titanium Grade 2

Component	C	Fe	H	N	O	Ti
Wt.%	Max 0.1	Max 0.3	Max 0.015	Max 0.03	Max 0.25	99.2

Table No. 3: Various properties of CP Titanium grade2 (Ti)

Physical property	Metric
Density (g/cc)	4.51
Mechanical Property	
Hardness Rockwell B	80
Tensile Strength, Ultimate (Mpa)	344
Tensile strength, Yield (Mpa)	275 - 410

Chemical Properties

Titanium readily reacts with oxygen at 1,200 °C (2,190 °F) in air, and at 610 °C (1,130 °F) in pure oxygen, forming titanium dioxide. It is however; slow to react with water and air at ambient temperatures because it forms a passive oxide coating that protects the bulk metal from further oxidation. When it first forms, this protective layer a thickness of 25 nm in four years. Application of Titanium are Pigments, additives, coatings, Aerospace and marine, Industrial, Consumer and architectural, Jewellery, Medical and Nuclear waste storage.

Dimensions of specimen were: 40 X 40 X 5 mm
No. of specimens used were 18 pieces

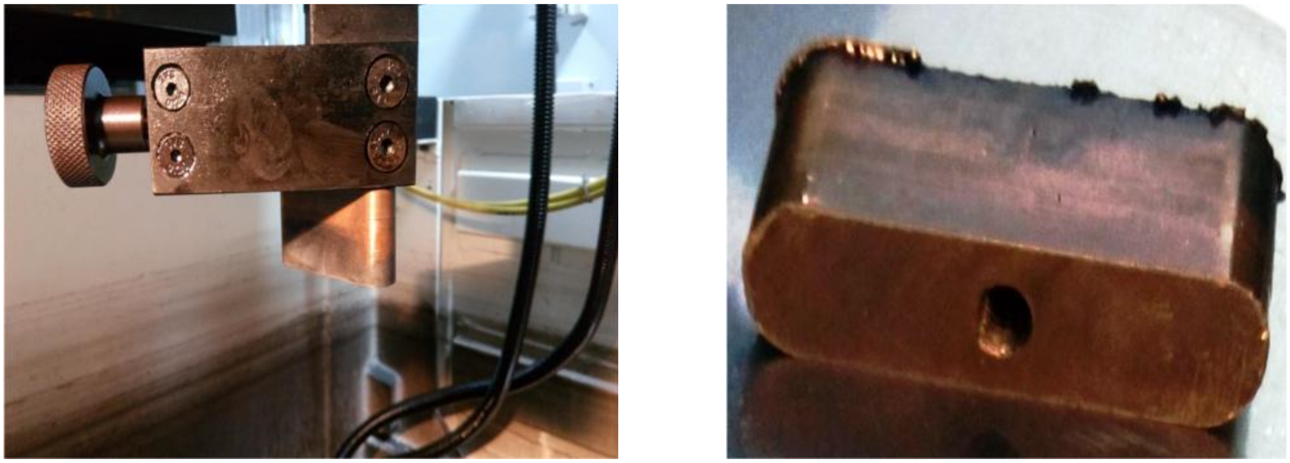

Figure 1: Copper Electrode

Therefore the experiment where perform on the CP Titanium (Ti) Grade2 specimen with varying level of the controlled variables levels and Burr were formed with the significant Material Removal Rate. That was measured later on with the help of a micro meter.

Figure 2: Weight measuring of Copper Electrode through Electronic Compact Scale

RESULTS & DISCUSSION

Table No.4: Tool Wear Rate(TWR) Response Table for Signal to Noise Ratios – "Smaller-is-better"

Level	Tw	TON (Pulse on)	TAU (Pulse Off)	IP	IB	TDI	SV	SF
1	192.6	207.3	199.7	199.1	189.8	199.8	197.3	192.5
2	203.8	193.0	196.4	201.9	203.9	197.7	202.8	207.7
3	--	198.2	199.5	192.1	201.4	197.7	195.5	198.5
4	--	--	--	202.0	--	--	--	--
Delta	11.2	14.2	3.3	9.9	14.1	2.1	7.3	15.2
Rank	4	2	7	5	3	8	6	1

Table No.5: Mean Response Table for Tool Wear Rate (TWR)

Level	Tw	TON (Pulse on)	TAU (Pulse Off)	IP	IB	TDI	SV	SF
1	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
2	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
3	--	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
4	--	--	--	0.000000	--	--	--	--
Delta	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
Rank	5	1	4	3	6	8	7	2

Table No.6: Analysis of Variance for Tool Wear

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Tw	1	0.000000	0.000000	15.72	0.157
TON (Pulse on)	2	0.000000	0.000000	11.87	0.201
TAU (Pulse Off)	2	0.000000	0.000000	10.00	0.218
IP	3	0.000000	0.000000	4.61	0.327
IB	2	0.000000	0.000000	4.60	0.313
TDI	2	0.000000	0.000000	1.57	0.492
SV	2	0.000000	0.000000	3.69	0.346
SF	2	0.000000	0.000000	2.61	0.401
Error	1	0.000000	0.000000	--	--
Total	17	0.000000	--	--	--

Table No.7: Model Summary

S	R-sq	R-sq(adj)	R-sq(pred)
0.0000000	99.00%	83.06%	*

Main Effect Plots and Contour Plots for Tool Wear

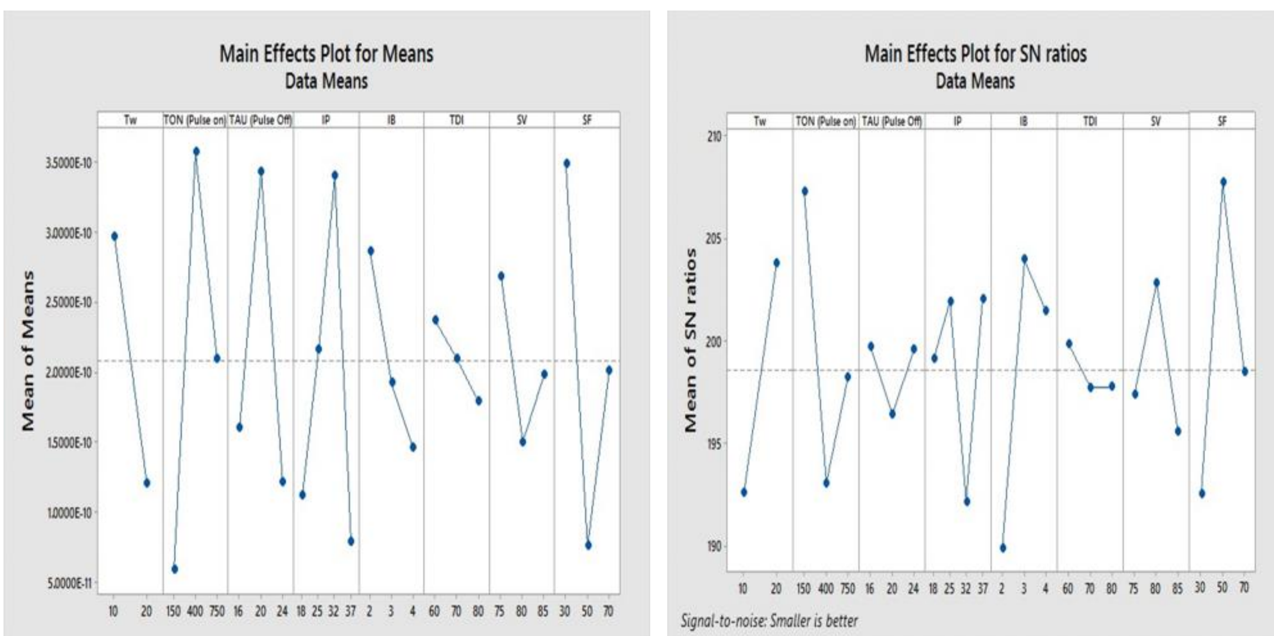

Figure .3: Main effects for Mean and SN Ratio for Tool Wear Rate

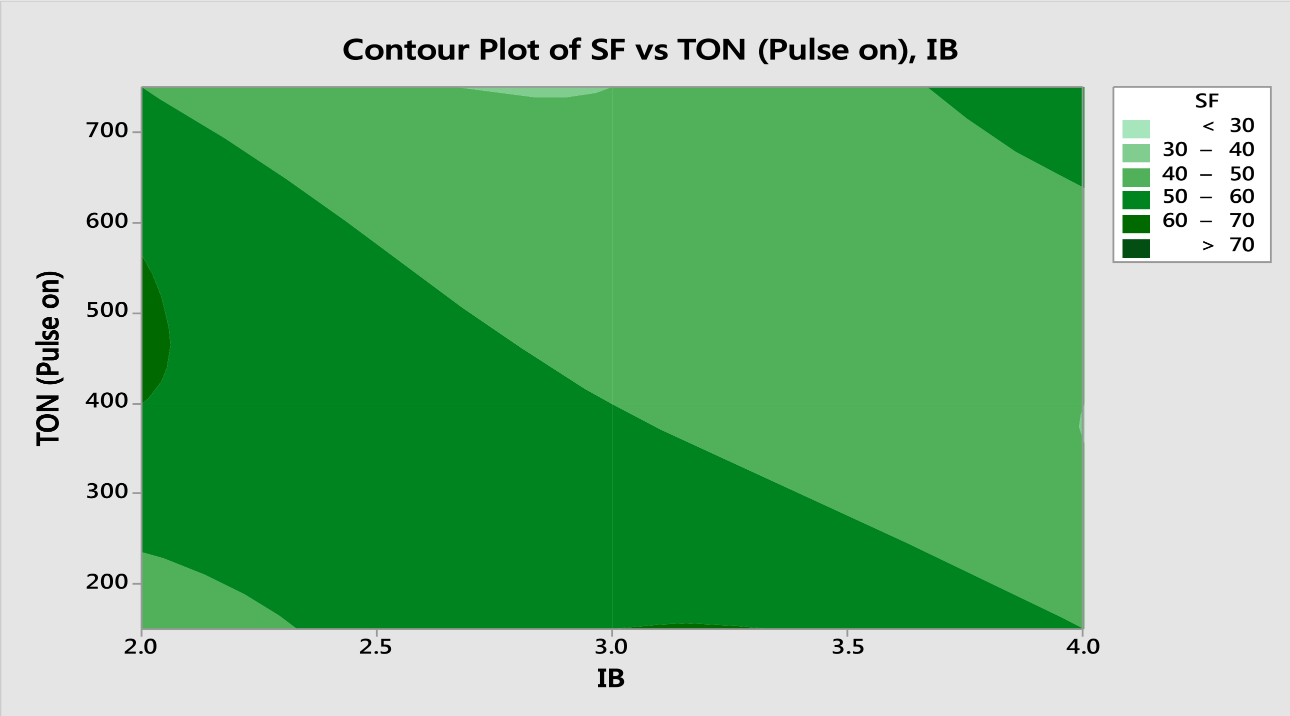

Figure. 4: Graph for Tool Wear with Copper Electrode on CP Titanium grade 2

Table No.8: Optimal Levels of the Parameters Tool Wear Rate (TWR).

Parameters	Tw	TON (Pulse on)	TAU (Pulse Off)	IP	IB	TDI	SV	SF
Levels	1	2	2	3	1	2	3	1
Values	10	400	20	32	2	70	85	30

According table no.8 during deburring machining through EDM the response table for Tool Wear Rate for Signal to Noise Ratios- "Smaller-is-better" were highly affected by SF followed by TON, IB, Tw, IP, SV, TAU, and TDI.

CONCLUSION

The present research work was performed at Tool Room Training Centre, Patna,Bihar, India.

- Deburring Operation was performed using Copper electrode at various level of parameters and the Material Removal Rate was measured as the response data.
- Table no.8 during deburring machining through EDM the response table for Tool Wear Rate for Signal to Noise Ratios- "Smaller-is-better" were highly affected by SF followed by TON, IB, Tw, IP, SV, TAU, and TDI.

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